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I, KAY WARD, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PQ 2498 for a patent by THE UNIVERSITY OF MELBOURNE filed on 27 August 1999.

WITNESS my hand this  
Twenty-ninth day of August 2000

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AUSTRALIA

Patents Act 1990

ORIGINAL

PROVISIONAL SPECIFICATION

Electrode Array with Non-Uniform Electrode Spacing

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The invention is described in the following statement:

## ELECTRODE ARRAY WITH NON-UNIFORM ELECTRODE SPACING

### Technical Field

This invention relates to electrode arrays for intra-cochlear implantation.

### Background Art

5 Intracochlear electrode arrays have been successfully utilised for many years as a stimulation mechanism for auditory prostheses. The function of the array is to provide electrical stimuli, by selecting one or more electrodes in the array and delivering a stimulus pulse from the electrodes, so as to produce an auditory percept in a patient.

10 The array is connected to a receiver stimulator unit, which in turn typically communicates transectaneously with an externally worn speech processor and sound transducer.

Over time, many different strategies have been applied both to analyse the speech and sound signals received by the transducer, and to provide  
15 appropriate stimuli to selected electrodes in the array so as to optimise the speech and sound perception of the patient.

However, commercially available cochlear implants all utilise electrode arrays in which the electrodes are substantially equally spaced, as has been conventional for 15 years or more. Recently, proposals have been made to  
20 provide an array which is shaped so as to be located near the inner wall of the scala tympani.

It is an object of the present invention to provide an electrode array which improves the fidelity of the reproduction of the audio spectrum in the percept of the cochlear implant recipient, for a given number of electrodes.

### 25 Summary of the Invention

Broadly, the present invention provides an electrode array in which the electrodes are not evenly spaced, but rather are differentially spaced in order to better map selected aspects of the physiology of the cochlea or to target selected regions.

30 According to one aspect, the present invention provides an intracochlear electrode array in which the electrodes are closer together at the apical end of the array. This may be achieved in various ways – for example,

by a uniformly graduated change in spacing, or by selecting two or more regions of the electrode array to have different spacings.

This aspect of the invention is based on several factors. It has been determined that it is desirable for the spacing of electrodes to correspond to uniform intervals along the organ of Corti. Because of the complex spiral shape of the scala tympani and its associated structures, this means in effect that smaller electrode spacings are appropriate the more deeply the array is inserted.

Further, if an electrode array is used which is shaped so as to be located operatively along the inner wall of the scala tympani, this effect is amplified both by the geometry of such placement, and by the greater insertion depth which is intended to be achieved by such devices. Preferably, the electrode spacing should be determined by the intercepts, along the intended array placement, of lines passing from a modiolar centre point through points spaced at equal increments along the organ of Corti. This arrangement generally maximises the uniformity of spectral coverage for a given number of electrodes, and accordingly the probability of good speech perception by an implant recipient.

According to another aspect, the present invention provides an electrode array with the spacing of electrodes varied so as to provide a higher density of electrodes at specific regions – for example, along a part of the array intended to stimulate one or more regions of the neural structures corresponding to frequency bands which are considered particularly important for speech recognition. This could be based on many different considerations – the essence of this aspect of the invention is simply to provide electrodes at reduced spacing in areas of particular interest.

#### Description

The invention will now be described with reference to the accompanying figures, in which:

- Figure 1 is a schematic illustration of a conventional electrode array in a scala tympani; and
- Figure 2 is a schematic illustration of an electrode array with non-uniform spacing of electrodes.

Referring to figure 1, this is based upon an X-Ray of an implanted device having a curved configuration, for example an array according to PCT/AU99/00391 by Cochlear Limited. It will be appreciated that this is a sectional view showing the scala tympani, which in fact curves into the page, but for present purposes the invention can be explained with reference to a two dimensioned projection. Dotted line 15 is the organ of Corti, with the X marks 18 being (in principle) equally spaced. It is emphasised that the drawing is schematic only, not anatomically correct and is intended only to explain the issue of relative geometry.

Electrode array 11 includes equally spaced electrodes 12. It will be appreciated that the apparent non-regularity of spacing is an artifact of the view shown, as in practice the device will often lie with bends or kinks in the other dimensions so as to not appear regularly spaced in this view. The neural structures, in particular the spiral ganglion cells, extend radially outward from the organ of Corti 15. It is in fact these cells which are stimulated by the stimuli produced by the electrodes, and so orienting to the organ of Corti is a reasonable approximation to orienting relative to these structures.

Various radial lines are shown extending from the modiolar centre 19. Essentially, as the curvature of the scala tympani increases apically, so the electrode spacing required to define equal increments along the organ of Corti 15 becomes smaller. The closer the array lies to the inner wall, the greater this effect.

It may also be desired to take into account two further effects. The structures are considerably more complex than is apparent from the schematics. At the basal end of the scala tympani, the organ of Corti lies further upward (see 16) and the spacing of the most basal electrodes could be reduced to take account of this. At the apical end, there is a greater offset between the organ of corti 15 and the underlying cell bodies, and again the spacing could be adjusted to account for this effect.

Figure 2 illustrates schematically an electrode array 20 with non-uniform spacing between electrodes, the spacing becoming smaller towards the apical end. This array is curved so as to (ideally) lie along the inner wall of the scala tympani 10.

It will be appreciated by those skilled in the art that the present invention can be readily manufactured by existing techniques, and could be of any desired electrode geometry or cross-sectional shape. The present invention is concerned with the spacing of the electrodes, not their construction.

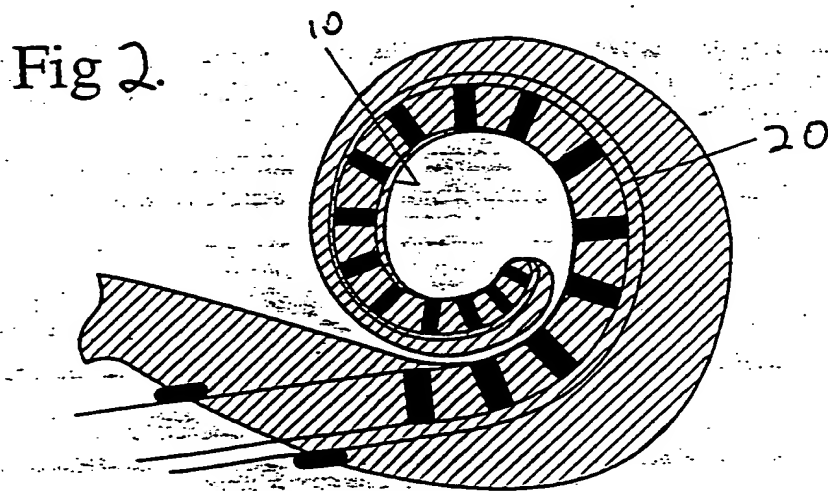
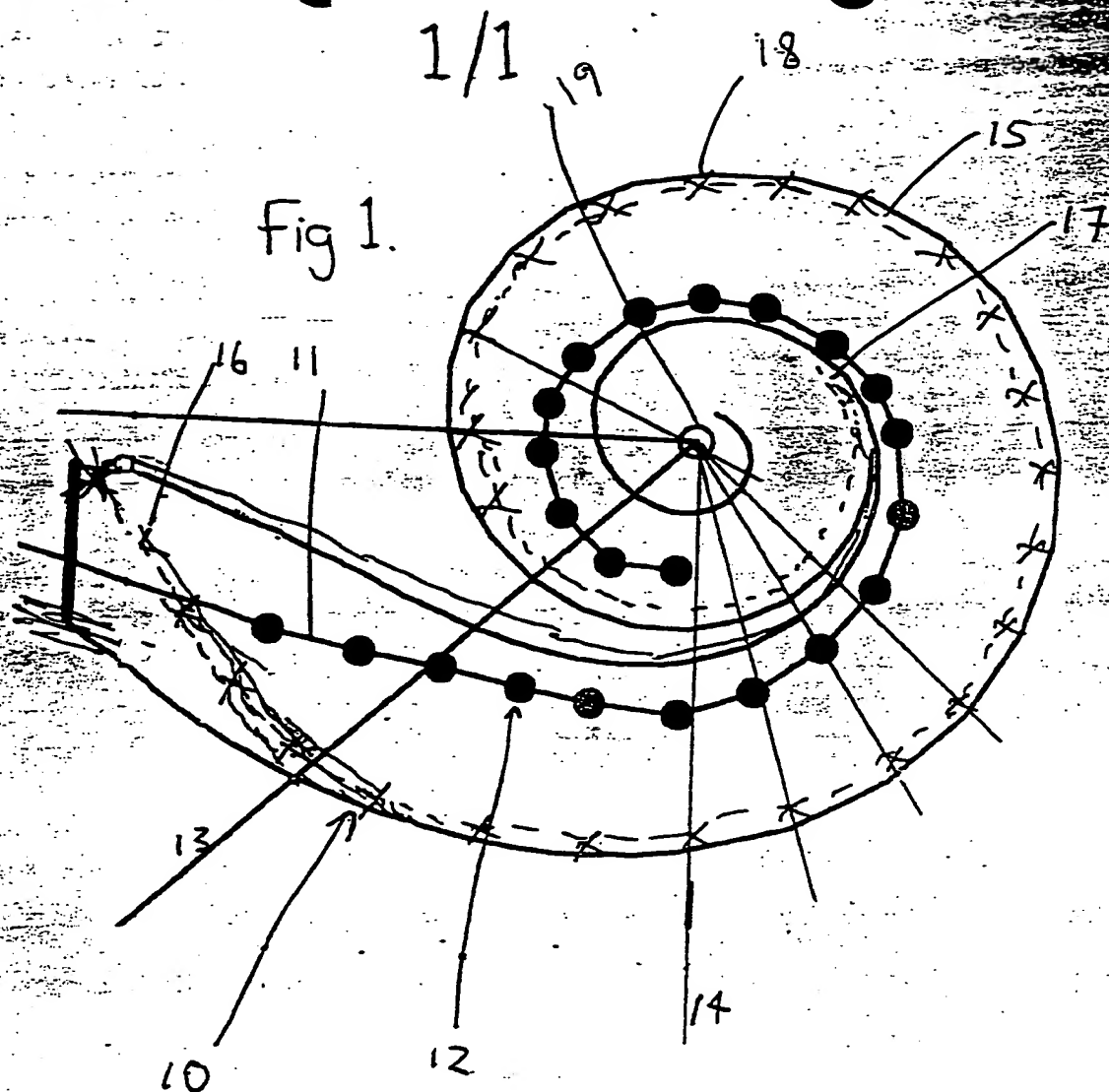
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